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from

Department of Physics

Florida State University

Radio Astronomy Programme

Period

August 1, 1965 through January 31, 1966

Submitted by

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Principal Investigator

ABSTRACT

The Radio Observatory has recently been moved to a new and quieter site several miles south of Tallahassee and is fully operative at the time of writing. Observations have been in progress since October, 1965. Reception conditions have been exceptionally good and the records obtained are of a high quality. Left and right-hand components of the different types of bursts have been compared at various frequencies using several different chart speeds and time constants. Correlation and phase measurements have been made at 18 Mc/s. so that all the polarization parameters may be determined at this frequency.

18 Mc/s. phase-switched interferometers are in operation at Tallahassee and St. Osyth.

A new experiment is in progress to study the millisecond pulses which have been observed in the Jupiter radiation.

The North-South line of overseas stations has almost completed a series of observations which began on September 1, 1965, using high-speed recorders for comparison of burst characteristics between the five sites.

Editing of records for the NASA Space Science Data Center continues and the Catalog of Jupiter Activity for 1961-1964 has been completed and circulated.

A Jupiter activity prediction system, using the Io correlation, has been introduced and has been used to arrange special experiments, equipment checks, etc.

Observations of the NASA radio beacon satellites are being made for measurement of the total electron content of the Earth's ionosphere.

1. Introduction.

The Radio Observatory has been moved to a new and quieter location several miles to the south of Tallahassee and is now fully operative, in spite of several delays involving administrative matters and delivery of equipment by manufacturers. Unqualified approval of the land requested in the National Forest Area for the out-station a few miles from Tallahassee has yet to be obtained and funds have not been available for clearing the alternative sites that have been offered. It is hoped that these items can be solved early in the new year.

Several minor faults were present in the 18 Mc/s. polarimeter electronics developed by Aerospace Research, Inc. These have involved returning units to the factory for modification and only one unit at a time has been available for observations at Tallahassee during the present apparition. For these reasons the two outstations required for the spaced-site polarization observations in Jamaica and in the Tallahassee National Forest area are unlikely to be fully operative until later in the year. Everything else has been ready and available for several months. Fortunately, reception conditions are considerably better now than they have been for several years and this should allow the observing season to be extended considerably both in 1966 and 1967. The complete polarization experiment comparing the four parameters from three separated sites at 18 Mc/s. should prove to be exceptionally interesting in the light of some of the new data taken at Tallahassee during the present apparition.

2. Observational Programme.

(i.) Polarization Measurements.

The polarization of the radiation has been studied in greater detail during the 1965-66 apparition. Left and right-hand components of the different types of bursts have been compared at 16, 18 and 22 Mc/s. using several different chart speeds and time constants. Correlation and phase measurement has also been made at 18 Mc/s. so that all the polarization parameters may be determined at this frequency. While the polarization continues to be predominantly right-handed at all frequencies a number of new and interesting variations have been observed particularly at the lower frequencies. Preliminary results at 18 Mc/s., for example, indicate that both the degree of polarization and the axial ration may vary considerably during a single burst of only a few seconds duration. On some occasions opposite polarizations have been observed at 16 and 18 Mc/s. On other occasions the polarization has been observed to change systematically from one sense to another during the course of an event. A typical record is shown in Figure 1. Polarization measurements have also been included in the millisecond pulse experiment described in the following section.

Observations have also been made at 12.5 and 26 Mc/s. but these latter have been less rewarding. At 12.5 Mc/s. the problem of interference has often been serious while at 26 Mc/s. the Jupiter radiation has been considerably less prolific.

(ii.) Millisecond Pulse Experiment.

The presence of pulses having durations of less than

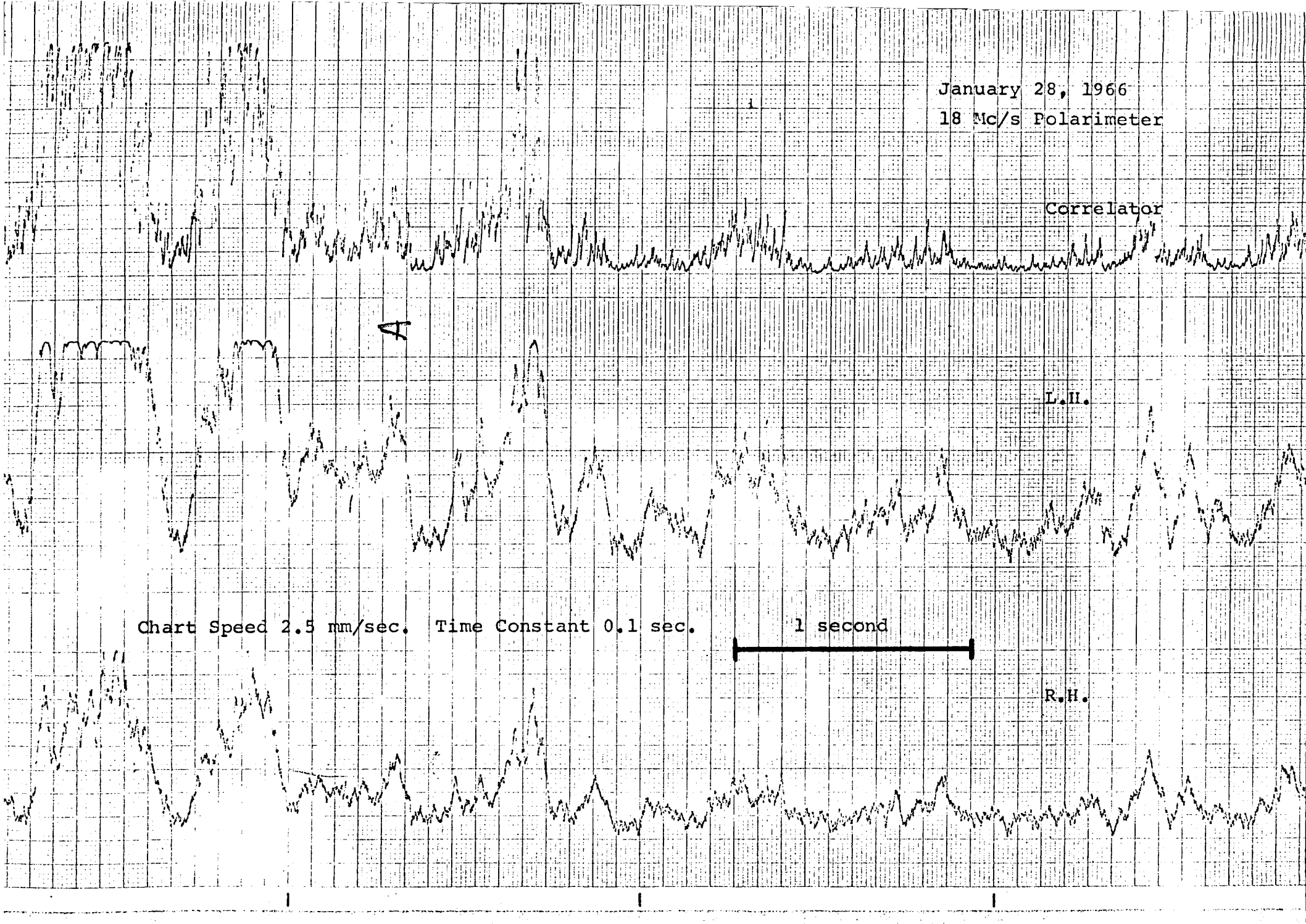

Figure 1. Typical record from the 18 Mc/s Polarimeter.

0.1 second in Jupiter decametric radio emission was reported originally by Kraus (1) and by Gallet. (2) Some observers have reported that they have observed no pulses this short or that they have been very rare. More recently Riihimaa (3) has made a study of the durations, and spectral characteristics of the pulses over a small frequency range from 18.2 to 19.2 Mc/s.

The first requirement for an investigation of these pulses is conclusive identification since static can produce similar effects. To aid in identification recordings were made at 16, 18 and 22 Mc/s. of the left and right-handed polarized components of incoming radiation using the two receiver-hybrid method [Barrow (4)] to eliminate the necessity for switching. Static pulses would not show circular polarization. Total power recordings were also made at 14 Mc/s. and at 18 Mc/s. using an antenna having a null in the direction of Jupiter. Any pulses received on this latter antenna must come from a source other than Jupiter. A phase-switched interferometer operated at 18 Mc/s. throughout observing periods as an additional means of identifying that Jupiter was active during the period. The receiver detector outputs were recorded on an 8-channel Brush recorder usually at a chart speed of 50 mm/sec. It was determined by experiment that pulse durations from 5 milliseconds upwards could be measured. Pulses satisfying all the conditions for having a Jovian origin have been recorded on many occasions. These pulses have durations usually less than 40 milliseconds and often less than 10 milliseconds. Typical pulse separation is about 100 milliseconds but on occasion isolated pulses appear with separation

of several seconds. The pulses show a variety of typical burst structures and appear to have some connection with the $120° = \lambda_{III}$ (1957.0) region of Jupiter. An example is shown in Figure 2. Observations and analysis of the recordings are continuing.

3. Analysis Programme.

(i.) Data Reduction.

A detailed burst-by-burst analysis of the high-speed records taken during the 1965-6 apparition [2(i.), (ii.)] is already in progress. A team of students has been trained to read off and to tabulate the burst characteristics. Preliminary reports are to be presented at meetings in March and April (see under Publications.)

(ii.) Catalog of Observations and Editing of Records for Microfilming.

A catalog of Jupiter observations made at the F.S.U. Radio Observatory and associated stations from 1961 through 1964 has been compiled and was distributed in November, 1965. Editing of low-speed records for 1962 and 1963 is continuing in preparation for copying for the NASA Space Science Data Center. Low-speed records from 1965 will be available for editing at the end of the 1965-1966 observing season in early March. The millisecond pulse experiment has yielded many very long high-speed records showing burst structures and polarization in great detail. It is proposed to make continuous 16 mm. microfilm copies of these records which are, at present, unique in the study of Jupiter.

(iii.) Solar-Jupiter Relationships.

Resch (5) has searched for a possible Solar-Jupiter

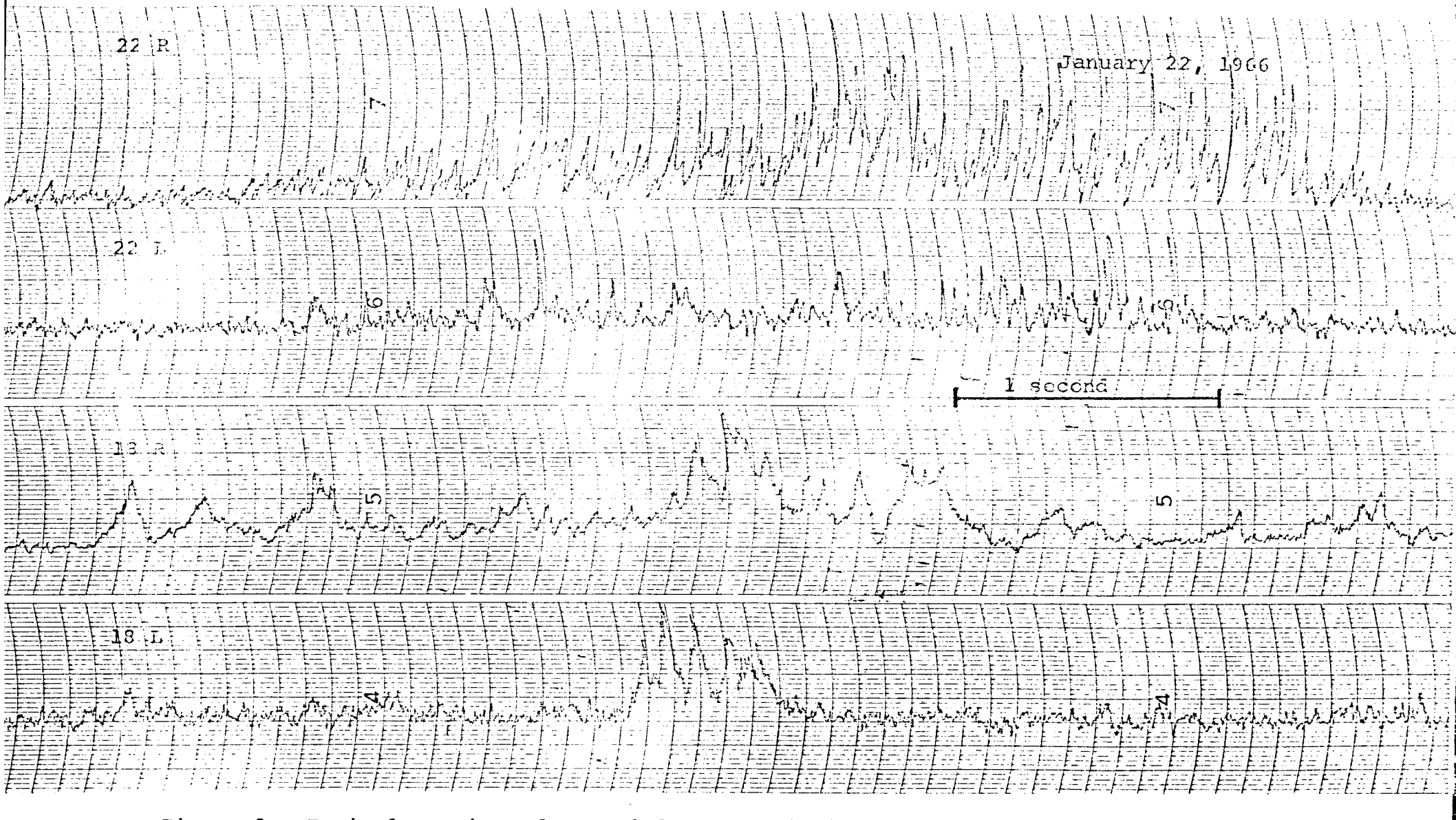

Figure 2. Typical section of record from the millisecond pulse experiment. Chart Speed 50 mm/sec., Time Constant 5 milliseconds.

relationship using cross-correlation techniques, a Chree analysis, and an attempt to predict the interaction of M region streams with Jupiter's magnetosphere using Chapman's theory of the continuous emission stream curve. The cross-correlation studies yielded some positive correlation at approximately the expected delay times (5 - 8 days); however, the lack of significance level, and inconsistency of the correlation from year to year indicates the unreliability of this type of analysis. On the other hand, the Chree analysis is a well known demonstrative of the 27 recurrence tendency between M region streams and geomagnetic disturbances. When applied to the Jovian radiation, however, no recurrence was apparent. Finally, the equations of motion of the M region streams were worked out using Chapman's theory so that the time of interaction with Jupiter's magnetosphere could be predicted from a knowledge of the time of interaction with the Earth's magnetosphere. The predictions were compared with observations of Jupiter's radio emission during 1961-1963 and again yielded negative results.

Present investigations are considering the possibility that a Solar-Jupiter correlation might be masked by the strong Io effect. Attempts will be made to subtract out all activity that can be said to be Io induced and the above mentioned analysis will then be performed on the remaining activity.

In a related problem, Gruber (6) has suggested that the different probabilities of Jupiter activity observed before and after opposition are due to the different aspects of Jupiter's magnetosphere presented toward Earth. To test this hypothesis Resch and Capone are attempting to calculate the size and shape

of Jupiter's magnetosphere, seen from Earth, as a function of time and solar wind parameters.

4. Future Plans.

The 18 Mc/s. four parameter polarization experiment and also the millisecond pulse experiment have both yielded a great deal of data and have both involved high-speed recording techniques. A detailed burst-by-burst analysis will be necessary for each period of activity. It is already clear that the amount of data to be handled is going to be very large and this will increase further during the next Jupiter apparition as additional systems are added to the present installations. It appears that an urgent need for the future will be for the data to be taken and processed automatically and presented directly to the computer without the intermediate manual procedure at present necessary. The feasibility and the cost of doing this is at present being investigated.

Both the axial ratio and the degree of polarization have been found to vary considerably at 18 Mc/s. during the course of a single burst of only a few seconds duration. It would be of considerable interest for the future to apply the four parameter measuring technique to 16 Mc/s. as well as 18 Mc/s. with the additional modification of a considerably shorter overall time constant so that the shortest radiation pulses can be studied for similar variations.

5. Visitors.

Dr. E. E. Baart, Director of the Rhodes University Radio Observatory, has been working at Florida State University as

a Visiting Carnegie Fellow since August 1965. He returns to South Africa in June, 1966.

References

1. Kraus, J. D., Proc. I.R.E., 46 266 (1958).

2. Gallet, R. M., Chapter 14 in Planets and Satellites III, (University of Chicago Press, Illinois, 1961).

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4. Barrow, C. H., Astrophys. J., 135, 847 (1962).

5. Resch, G. M., M.S. Thesis, Florida State University (1965).

6. Gruber, G. M., Nature (London) In Press. (1966).

6. Publications August 1, 1965, through January 31, 1966.

"A Catalogue of Jupiter Activity, 1961-1964," Morrow, D. P., Barrow, C. H., Resch, G. M. (Florida State University Radio Observatory Report).

"Report of the Florida State University Radio Observatory," Barrow, C. H. Astronomical Journal, 70, 767 (1965).

"An Investigation of a Possible Correlation between Jupiter Activity and Solar Activity," Resch, G. M. M.S. Thesis, Florida State University, December, 1965.

"Radiostøyen fra Jupiter," Torgersen, H. Fra Fysikkens Verden, Nr. 4, 77 (1965) (In Norwegian).

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"Solar-Jupiter Relationships," Resch, G. M. and Barrow, C. H. Bulletin of the American Physical Society (Abstract in Press).

In preparation:

"Polarization of the Jupiter Radiation," Barrow, C. H., Baart, E. E., Morrow, D. P. Paper for URSI Meeting, Washington, D.C., April, 1966 and more detailed account for Journal Publication.

"Millisecond Pulses in Jupiter Radiation," Baart, E. E., Barrow, C. H., Lee, R. T. Paper for American Astronomical Society Meeting, Hampton, Virginia, March, 1965 and more detailed account for Journal publication.

Three papers for Florida Academy of Sciences Meeting, St. Petersburg, Florida, March, 1966.

7. Personnel Working on the Grant:

(a.) Tallahassee

C. H. Barrow, Assistant Professor and Principle Investigator.

E. E. Baart, Visiting Carnegie Fellow

L. Capone, Graduate Assistant

R. Lee, Graduate Assistant

D. Morrow, Graduate Assistant

G. M. Resch, Graduate Assistant

C. Falaney, Electronics Technician

*L. McCord, Electronics Technician

G. R. Adcock, Undergraduate Assistant

B. Brown, Undergraduate Assistant

*J. Butler, Undergraduate Assistant

R. Gingras, Undergraduate Assistant

*G. Green, Undergraduate Assistant

J. Herr, Undergraduate Assistant

L. Joeris, Undergraduate Assistant

W. Schaeffer, Undergraduate Assistant

J. Van Pelt, Undergraduate Assistant

*T. Wurzbach, Undergraduate Assistant

*Terminated during the period.

(b.) St. Osyth

F. W. Hyde, Radio Engineer and Director of St. Osyth Station (Self supported).

F. Cooper, Technical Assistant

R. Hawkins, Technical Assistant

P. Lundburg, Technical Assistant

J. Slatter, Technical Assistant

D. Crosswell, Part-time Secretary

Personnel Associated with the Project:

(a.) Grahamstown, South Africa

E. E. Baart, Senior Lecturer in Physics and Director of Radio Astronomy.

G. M. Gruber, Lecturer in Physics

P. J. Harvey, Graduate Assistant

P. Terry, Graduate Assistant

(b.) **Local supervisors** for the 1964 spaced-site observations.

S. E. Okoye, Lecturer in Physics, University of Ibadan

J. Catala, Professor of Physics, University of Valencia

H. Torgersen, Engineer, Technical University of Trondheim

R. W. H. Wright, Professor of Physics, University of the West Indies

Groups of from 3 to 5 undergraduate assistants were employed on the Grant at St. Osyth, Ibadan, Valencia and Trondheim during the period August 1 through December 15, 1964.